

THE BASE OF THE ANISIAN. A CANDIDATE GLOBAL STRATOTYPE SECTION AND POINT FROM CHIOS ISLAND (GREECE)

G. Muttoni, D. V. Kent and M. Gaetani

Introduction

In recent years there have been reappraisals of a variety of significant stratigraphic sections across the Spathian/Anisian (Early/Middle Triassic) boundary (Wang, 1985; Bucher, 1989; Tozer and Talon, 1990; Gradinaru, 1991; Gaetani et al., 1992). At present, sections in Oman, Dobrudgea (Romania) and Chios (Greece) appear to be the most relevant sections described in pelagic Tethyan environments. All of them are comprised of pinkish to reddish nodular limestones with low sedimentation rates.

The Himalayan sections do not seem to be suitable, essentially because the boundary occurs within the so-called Niti Limestone (Nicora et al., 1984), where ammonoids are badly preserved and almost impossible to chisel out. As regards magnetostratigraphy it is worth noting that, although a paleomagnetic survey has not been attempted, the Color Alteration Index of conodonts (4 to 5) suggests that the region underwent high regional heating (more than 300 °C?) that may have reset the magnetization.

In SE China (Yangtze Platform) the critical interval is condensed and is characterized by mixed ammonoid faunas (Wang, 1985), whereas in Nevada the critical interval around the boundary falls within the poorly fossiliferous "Brown Sandstones" (Silberling and Wallace, 1969). As Bucher (1989) reports, the first ammonoid-bearing level above this terrigenous unit is the *J. welteri* horizon.

Thus, the most suitable sections for the Global Stratotype Section and Point (GSSP) of the base of the Anisian seem to be, at present, the western Tethyan Oman, Dobrudgea and Chios sections.

- (i) The paleontological content of the Oman sections has been described by Tozer and Talon (1990) (ammonoids) and Orchard (1994, in press) (conodonts). A magnetostratigraphic survey performed by Y. Gallet et alii gave no useful results (Gallet, pers. comm., March 1994).
- (ii) During the last ten years the Dobrudgea sections (Desli Caira and Agighiol) have been visited by several members of the International Subcommission on Triassic Stratigraphy (ISTS), under the leadership of E. Gradinaru (Bucarest). A summary on the ammonoid and conodont stratigraphic distributions was presented at the ISTS meeting at Lausanne (October 1991) by Gradinaru. Finally, samples for paleomagnetism, presently under study, have been recently collected at Desli Caira and Agighiol by the French team (Gallet et al., 1993).

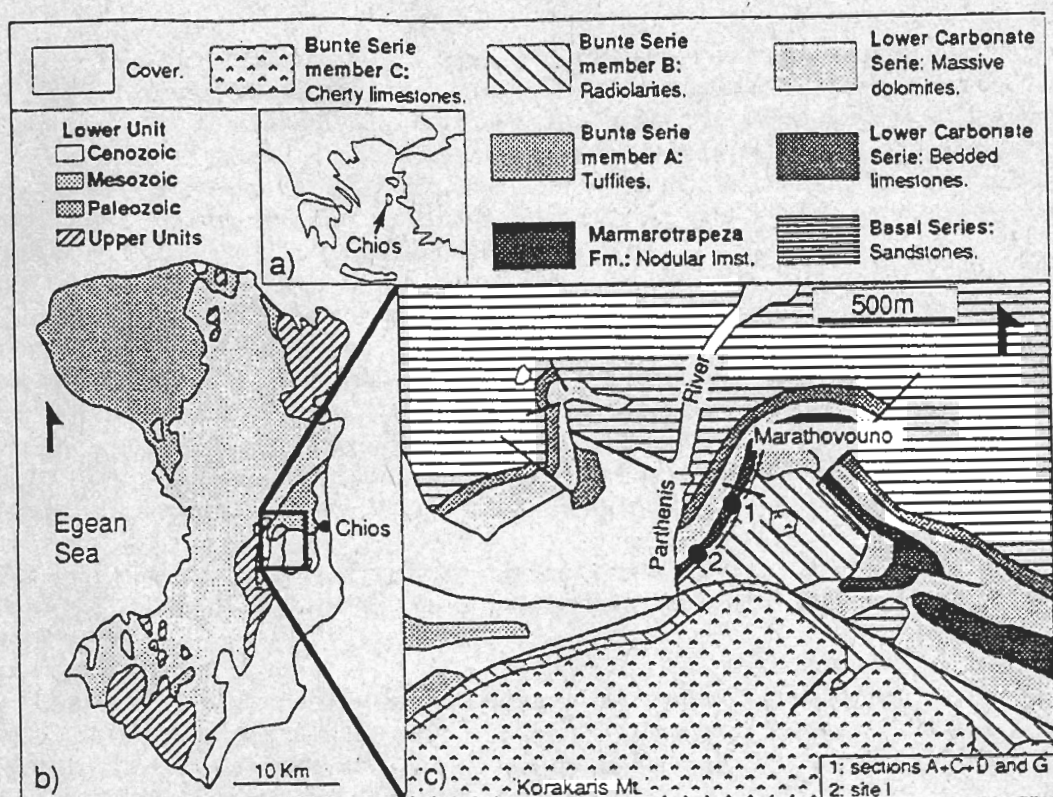


Fig. 1 (a) Geographic location and (b) simplified geological map of Chios Island (after Gaetani et al., 1992); (c) geological sketch map of the Marathovouno hillock area (after Lazzaroni, 1991).

- (iii) The Chios sections are located on the Island of Chios (Greece) (Fig. 1). Their paleontological content has been revisited by Gaetani et al. (1992) (ammonoids and conodonts) and Muttoni and Rettori (1994) (foraminifers). A comprehensive magnetobiostratigraphic study has been recently carried out by G. Muttoni, D. V. Kent and M. Gaetani (in preparation) at section A+C+D and section G of Gaetani et al. (1992), equivalent to sections CMII and CMI of Bender (1970) (Fig. 2). In this paper we anticipate part of the magnetostratigraphic results and we propose one of the Chios sections as a candidate Global Stratotype Section and Point for the base of the Anisian.

Paleomagnetic analysis

Sections A+C+D and G have been sampled stratigraphically, from base to top, with an average sampling interval of 25 cm. A site located a few hundred meters away and characterized by a different bedding attitude (site I) has also been sampled to perform a fold test which could hopefully constrain the age of acquisition of the characteristic remanence. The total number of thermally demagnetized specimens is 232. Remanence measurements were performed in a 2G 3-axis cryogenic magnetometer located in a magnetically shielded room at the paleomagnetism laboratory of Lamont-Doherty Earth Observatory.

Vector end point demagnetograms reveal three progressively isolated components. After removal of a low unblocking temperature present-day field or spurious component between 0 and 200 °C, and of a "B" component with north-westerly declinations and positive inclinations between 300 and 600 °C (which is not discussed here for brevity purposes), a dual polarity northwest-and-down or south-east and up "C" component regarded as characteristic and carried by hematite is revealed between 625/650 and 680 °C. At site I the characteristic "C" component has been isolated in only two specimens.

The precision parameter of the three site-mean "C" directions increases by a factor of 9.8 with full (100%) correction for bedding tilt. Although site I is represented by only two sample directions, the fold test on the site-means is positive at the 95% level of confidence according to the criteria of McFadden and Jones (1990). Thus, the available data seem to suggest that the reversal-bearing characteristic component pre-dates tilting which, according to Jacobshagen (pers. comm., 1993), must have been caused by the Late Cretaceous and/or Eocene compression related to the structuration of the Hellenides mountain range.

The overall mean direction after full (100%) tilt correction is Dec. 274.3°, Inc. = 33.1° ($\alpha_{95} = 11.4^\circ$, $k = 118$, $N = 3$) and points to a paleolatitude of 18°N for the characteristic magnetization.

The polarity option chosen (i.e., north west and down = normal) and the derived paleolatitude are compatible with the paleogeographic reconstruction of the western Tethys of Marcoux et al. (1993), where the Serbo-Pelagonian zone, to which Chios belongs, was located north of the equator during the Middle Triassic, between 10° and 20°N.

A normal-reversed-normal polarity sequence has been recognized at both sections A + C + D and G. Following the nomenclature introduced by Alvarez et al. (1977), the polarity zones have been named, in ascending stratigraphic order, Chios A⁺, Chios B⁻ and Chios C⁺.

At sections A + C + D and G the ChiosA⁺/ChiosB⁻ boundary occurs at the base of a cm-thick condensed horizon. The overlying ChiosB⁻/ChiosC⁺ boundary is affected by a minor fault at section A + C + D, whereas at section G occurs at the base of a cm-thick hard ground (Fig. 2). Paleontological observations suggest that the hiatuses present at both the condensed horizons and the hard grounds are not very important.

The position of the Early/Middle Triassic boundary

During Triassic time, biochronology of pelagic limestones is mainly based on ammonoids and conodonts.

At the Marathovouno sections, the appearance of the conodont *Gondolella timorensis* Nogami slightly predates the first occurrence of the ammonoid assemblage with *Aegeiceras*, *Paracrochordiceras*, *Paradanubites* and *Japonites* (Fig. 2). In Gaetani et al. (1992), the position of the Early/Middle Triassic boundary was placed at the base of this ammonoid assemblage mainly for two reasons.

LOWER TRIASSIC		MIDDLE TRIASSIC	Series
OLENOKIAN		ANISIAN	Stages
SPATHIAN		AEGEAN	Substages
	Subrobustus zone	~ Caurus zone	British Col. amm. zones (Bucher, 1989)
Prohungarites - Subcolumbites beds	Haugi zone	J. welleri beds ~ Caurus zone	Nevada amm. zones (Bucher, 1989)
Prohungarites - Subcolumbites zone (Kummel 1973)		Aegeiceras/Japonites beds (Gaetani et al., 1992)	Tethyan ammonoid zones
MARMAROTRAPEZA FORMATION			Formation
			Polarity

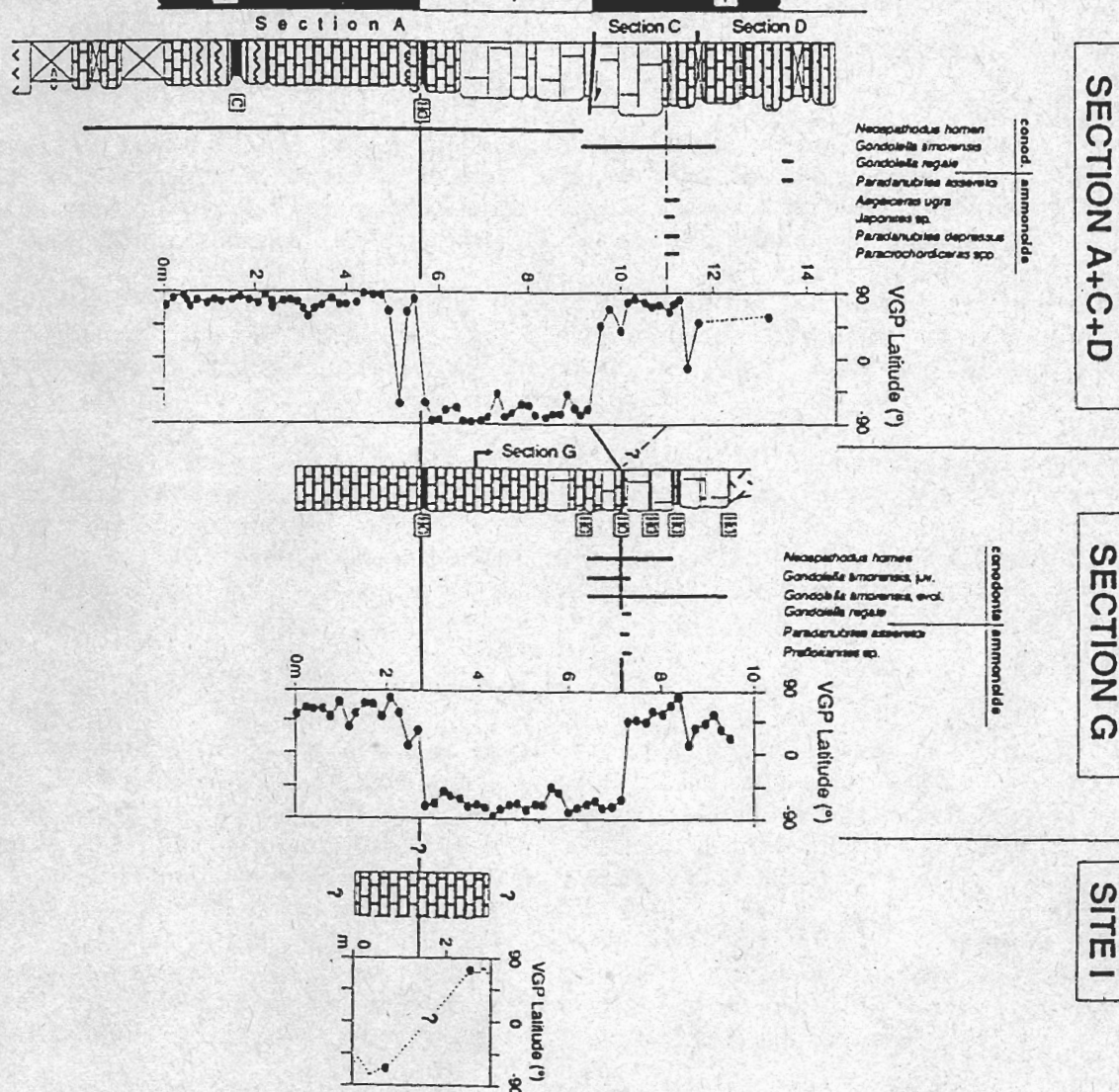


Fig. 2 Lower/Middle Triassic boundary-bearing sections A+C+D and G of Gaetani et al. (1992). The central columns show the VGPs latitude plotted as function of stratigraphic thickness and the derived polarity sequence. The occurrence/appearance of the most important conodonts and ammonoids used to define the boundary are indicated by solid bars. Polarity zones are designated by letters with the prefix "Chios" in ascending alphabetical order, followed by "+" (normal) or "-" (reversed). The Early/Middle Triassic boundary on ammonoids falls close to the base of the polarity zone "Chios C+". In the lithology logs, "HG" stands for hard ground and "C" for condensation.

- 1) The ammonoid assemblage marks a real change in the ammonoid evolution. Several Anisian genera first appear, whilst most typically Spathian forms are absent. The *Aegeiceras*, *Paracrochordiceras*, *Paradanubites* and *Japonites* assemblage is the oldest so far described in Anisian sections, and is considered coeval with the *J. welteri* horizon of Nevada (Bucher, 1989). A similar assemblage characterizes the earliest Anisian sediments of Oman (Tozer, and Talon, 1990) and of Dobrudgea (Romania) (Gradinaru, 1991). In the central part of the Tethys, ammonoids of this assemblage are present in the so-called mixed fauna described by Wang (1985).
- 2) For historical reasons, in Triassic stratigraphy an ammonoid-based boundary is preferred to a conodont-based boundary, if the two are not coincident.

The ammonoid record is however not continuous in the Marathovouno sections, due to poor preservation conditions, whereas conodonts, although less abundant, constitute a more continuous record and their stratigraphic range may be described in terms of "appearance" rather than of "first occurrence", which is more appropriate for the ammonoid distributions.

The Early/Middle Triassic boundary traced at the occurrence of the Anisian ammonoid assemblage, and hence the base of the Anisian, lies close to the base of the normal polarity interval "Chios C⁻". However, the transition between the polarity intervals "Chios B⁻" and "Chios C⁻" is close also to the appearance of *Gondolella timorensis* (Fig. 2).

According to these observations, two options for the position of the base of the Anisian can be considered, either to maintain the base of the Anisian at the occurrence of the new Anisian ammonoid stock, or to start the Anisian at the first occurrence of *G. timorensis*. This latter option, useful in those sections where ammonoids are not present, implies the definition of a stage boundary cutting across an ammonoid zone but would make it almost coincident with a paleomagnetic polarity reversal.

Conclusions

The sections A + C + D and G provide a consistent pattern of magnetic reversals which can be correlated to the Early/Middle Triassic boundary, either placed on the basis of ammonoids or conodonts. Thanks to the rich paleontological content, the Marathovouno section A + C + D of Assereto et al. (1980) (= section CMII of Bender, 1970) is a good candidate as a GSSP for the base of the Anisian. The narrow sampling rate adopted tends to exclude the presence of undetected short polarity intervals.

The magnetostratigraphy from the Marathovouno hillock sections has been tentatively correlated to the Early Triassic South China sequence of Steiner et al. (1988) and the composite Early Triassic stratotype sections from the Canadian Arctic of Ogg and Steiner (1991).

As concerns the biostratigraphic correlations between Chios and the Arctic sections, according to Gaetani et al. (1992) and Bucher (1989) the *Prohungarites-Subcolumbites* Zone of Chios is correlative with the *Subrobustus* Zone in the Canadian Arctic-British Columbia, whilst the *Aegeiceras/Japonites* beds partly overlaps, in the Canadian Arctic-British Columbia, with the *Caurus* Zone. For these observations we may conclude that the polarity zones Chios A⁺ and Chios B⁻ correlate, respectively, with the polarity zones SpN1 and SpR2 of the Arctic stratotypes. On the other hand, the normal interval Chios C⁺ does not have a correlative in the Arctic sections, where the presence of a hiatus affecting essentially the Aegean (first substage of the Anisian) is

testified by the occurrence of the Middle Anisian *Varium* Zone immediately above the Spathian *Subrobustus* Zone.

A more detailed discussion on the paleomagnetism and magneto-biostratigraphy of the Chios sections is in preparation by G. Muttoni, D. V. Kent and M. Gaetani for submission to *Earth and Planetary Science Letters*.

References

- ASSERETO, R., JACOBSHAGEN, V., KAUFFMANN, G. and NICORA, A., 1980. The Scythian/Anisian boundary in Chios, Greece. *Riv. It. Paleont. Strat.*, 85 (1979): 715-736.
- BENDER, H., 1970. Der Nachweis von Unter-Anis ("Hydasp") auf der Insel Chios. *Ann. Géol. Pays Hellen.*, 19 (1967): 412-467.
- BUCHER, H., 1989. Lower Anisian Ammonoids from the northern Humboldt Range (northwestern Nevada, USA) and their bearing upon the Lower-Middle Triassic boundary. *Ecl. Geol. Helvetiae*, 82: 945-1002.
- GAETANI, M., JACOBSHAGEN, V., NICORA, A., KAUFFMANN, G., TSELEPIDIS, V., FANTINI SESTINI, N., MERTMANN, D. and SKOURTSIS-CORONEOU, V., 1992. The Early-Middle Triassic boundary at Chios. *Riv. It. Paleont. Strat.*, 98(2): 181-204.
- GALLET, Y., BESSE, J. and THÉVENIAUT, H., 1993. Middle and Late Triassic Magnetostratigraphy. *Terra abs.*, suppl. n. 1 *Terra Nova*, 5: 75, EUG VII Strasbourg, 4-8 April, 1993.
- GRADINARU, E., 1991. An Integrated Biostratigraphy of the Spathian/Lower Anisian Boundary in North Dubrogea (Romania): a Test Case for the Tethyan Biostratigraphy. Symposium on Triassic Stratigraphy, Lausanne, October 20-23, 1991.
- LAZZARONI, R., 1991. Rilevamento della successione Triassica nell'area dello strato tipo Egeico (Chios; Grecia). *Sottotesi Univ. Milano*, 40 pp.
- MARCOUX, J., BAUD, A., RICOU, L.E., GAETANI, M., KRZYSTYN, L., BELLION, Y., GUIRAUD, R., MOREAU, C., BESSE, J., GALLET, Y. and THIEVENIAUT, H., 1993. Late Anisian (237 to 234 Ma). In: J. DERCOURT, L.E. RICOU and B. VRIELYNCK (eds.), *Atlas Tethys Palaeo-environmental Maps. Explanatory Notes*. Gauthier-Villars, Paris, pp. 113-134.
- MCFADDEN, P.L. and JONES, D.L., 1981. The fold test in palaeomagnetism. *Geophys. J. R. Astr. Soc.*, 67: 53-58.
- MUTTONI, G. and RETTORI, R., 1994. New biostratigraphic data on the Triassic of the Marathovouno hillock area (Chios Island, Greece). *Riv. It. Paleont. Strat.*, 99(4) (1993): 461-472.
- MUTTONI, G., KENT, D.V. and GAETANI, M., in preparation for *Earth Pl. Sc. Lett.* Magnetostratigraphy of a candidate Global Stratotype Section and Point for the base of the Anisian from Chios Island (Greece).
- NICORA, A., GAETANI, M. and GARZANTI, E., 1984. Late Permian to Anisian in Zaskar (Ladakh, Himalaya). *Rend. Soc. Geol. It.*, 7: 27-30.
- OGG, J.G. and STEINER, M., 1991. Early Triassic magnetic polarity time scale - integration of magnetostratigraphy, ammonite zonation and sequence stratigraphy from stratotype sections (Canadian Arctic Archipelago). *Earth Pl. Sc. Lett.*, 107: 69-89.
- ORCHARD, M.J., 1994 in press. Conodont biochronology around the Early-Middle Triassic boundary: new data from North America, Oman and Timor. *Proceedings of the Triassic Symposium, Lausanne, 1992. Memorie de Geologie*.
- SILBERLING, N.J. and WALLACE, R.E., 1969. Stratigraphy of the Star Peak Group (Triassic) and overlying Lower Mesozoic rocks, Humboldt Range, Nevada. *Prof. Pap., U. S. Geol. Surv.*, 592: 1-49.

- STEINER, M., OGG, J., ZHANG, Z. and SUN S., 1989. The Late Permian/Early Triassic Magnetic Polarity Time Scale and Plate Motions of South China. *J. Geophys. Res.*, 94: 7343-7363.
- TOZER, E.T. and TALON, T.J., 1990. Triassic ammonoids from Jabal Safra and Wadi Alwa, Oman, and their significance. *In* ROBERTSON A.H.F., SEARLE M.P. and RIES, A.C. (eds.), *The Geology and Tectonics of Oman Region*. Geol. Soc. Spec. Publ. 49: 203-211.
- WANG Yi-gang, 1985. Remarks on Scythian/Anisian boundary. *Riv. It. Paleont. Strat.*, 90 (1984): 515-544.

TOWARD A NONMARINE TRIASSIC TIMESCALE

Spencer G. Lucas

Introduction

In August 1992, at the 29th International Geological Congress in Kyoto, Japan, the STS approved a proposal by S. G. Lucas, V. Lozovsky and Cheng Zhengwu to form a working group on the nonmarine Triassic timescale (the proposal was published in *ALBERTIANA* 10, p. 41). The working group thus formed contains eight members: Spencer G. Lucas, Albuquerque, New Mexico, U.S.A. (chairman); Vladlen Lozovsky, Moscow, Russia (vice-chairman); Cheng Zhengwu, Beijing, China (vice-chairman); Inna Dobruskina, Jerusalem, Israel; Heinz Kozur, Budapest, Hungary; Roberto Molina-Garza, Albuquerque, New Mexico, U.S.A.; Paul Olsen, Palisades, New York, U.S.A.; and R. S. Tiwari, Lucknow, India. I hope that one or two more members will be added to the working group, preferably from South America or Africa. Expertise and research interests of the members of the working group encompass sequence stratigraphy, cyclostratigraphy, radiometric dating, magnetostratigraphy, palynology, megafossil paleobotany, invertebrate micropaleontology (ostracods, charophytes and conchostracans), paleoichnology and vertebrate paleontology.

The working group first met in Albuquerque last October during the International Symposium and Fieldtrip on the Nonmarine Triassic (see report by Lucas and Morales elsewhere in this issue). During this meeting, the group discussed five issues raised by the chairman: (1) nomenclature of Triassic time intervals based on nonmarine chronology; (2) relative significance of different fossil groups to nonmarine Triassic biochronology; (3) nonmarine type sections (standards) for intervals of Triassic time; (4) integration of radiometric ages and magneto-chronology with biochronology; and (5) relationship of the working group's efforts to current work on the SGCS (standard global chronostratigraphic scale) for the marine Triassic. This discussion demonstrated general consensus on key matters of philosophy and procedure early in the history of the working group. Here, I discuss these issues briefly and present the consensus of the working group.